SIMULATING INFILTRATION TESTS IN THE BOX CANYON UNSATURATED FRACTURED BASALT

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RESEARCH OBJECTIVES

The objective of this work is to examine the applicability of conceptual and numerical modeling methodologies utilized at Yucca Mountain, Nevada, to study the Box Canyon, Idaho, infiltration test data. The intent is to build confidence in the utility of these approaches for simulating mechanisms controlling infiltration in fractured rock and to substantiate the use of models as predictive tools for the potential Yucca Mountain repository. As such, the Box Canyon site serves as a natural analog to Yucca Mountain for studying flow processes in fractured rocks.

APPROACH

The site consists of layered basalt flows containing horizontal and vertical columnar fractures resulting from cooling of the basalt. The geological and numerical model for the Box Canyon site is used to address issues related to flow of infiltrating water in the basalt hydrogeological system. Field data at the Box Canyon site were gathered from pneumatic and infiltration tests almost entirely within the upper basalt flow. The elevation of the ground surface along with the location of instrumented vertical and slanted boreholes is shown in Figure 1. The box outline indicates the perimeter of the infiltration pond used to contain the ponded water at the ground surface. The numerical modeling effort was conducted using TOUGH2 with the EOS3 module to simulate both mobile water and gas phases though the fractures and matrix of the basalt rock using the dual-permeability approach. Calibration of the model involved analysis of both pneumatic and infiltration test data.

ACCOMPLISHMENTS

Calibration results indicated that the fracture-continuum porosity was a very sensitive parameter, controlling the arrival time of the infiltration front. The fracture-continuum porosity of the upper basalt flow ranged from 0.01 to 0.02. The matrix-continuum permeability was increased relative to the core measurements to reflect the influence of the highly permeable vesicular zones on the field scale. Finally, the interfacial area between the fracture and matrix continua was multiplied by factors of 0.01 and 0.1 when using the Corey and van Genuchten relative permeability functions, respectively. Both fracture-continuum porosity and matrix-continuum permeability values were representative of independently measured values.

SIGNIFICANCE OF FINDINGS

In general, a consistent set of parameters for a 3-D dual permeability model was obtained that allowed the model to replicate the majority of the infiltration test data. Although the dual-permeability approach is also applied to explain groundwater flow at Yucca Mountain, the vastly different scales of Box Canyon and Yucca Mountain imply that upscaling is an issue when comparing parameter values. The applicability of the dual-permeability modeling approach to both Box Canyon and Yucca Mountain does, however, build confidence in its ability to simulate infiltration processes in variably saturated fractured rocks.
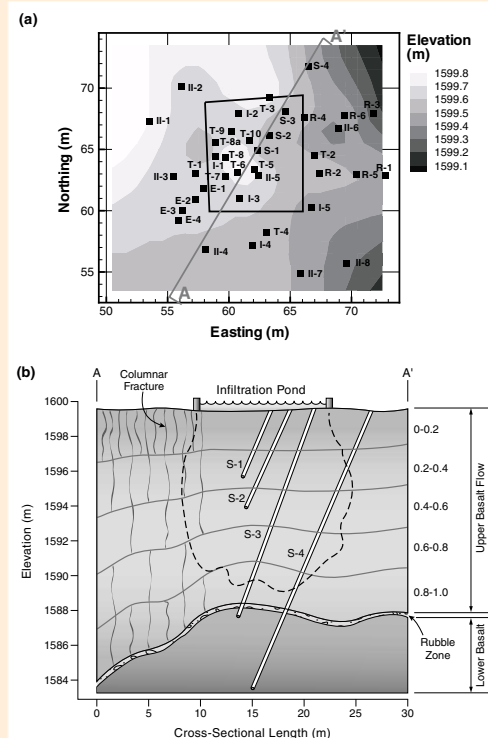

Figure 1. Elevation of (a) ground surface and (b) cross section through upper basalt flow.

RELATED PUBLICATIONS

Unger, A., B. Faybishenko, G.S. Bodvarsson and A. Simmons, A 3-D model for simulating ponded infiltration tests in the variably saturated fractured basalt at the Box Canyon Site, Idaho, J. of Contaminant Hydrology, submitted.

Simmons, A., A. Unger, and M. Murrell, Natural analogs for the unsaturated zone, ANL-NBS-HS-000007 Rev 00., Las Vegas, Nev., CRWMS M&O, 2000.

ACKNOWLEDGEMENTS